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Evaluation of Weed Control and Crop Safety with Herbicides in Open Field Tree Nurseries

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Open field production of fruit and nut-tree nursery stock depends upon preplant soil fumigation, extensive tillage, and hand-labor throughout the growing season for adequate weed control. Because methyl bromide, the favored fumigant, is being phased out because of environmental concerns and the costs of both fuel and labor continue to rise, herbicides are likely to become a more important weed management tool in the tree nursery industry. Two trials were conducted to evaluate weed control and crop safety with several herbicides applied following fumigation with methyl bromide or 1,3-dichloropropene in central California stone-fruit nurseries. PRE and POST-directed applications of several labeled and unlabeled materials were applied in a band over seeded peach rootstock or applied after emergence with a drop-nozzle spray boom. Crop productivity and weed control were monitored throughout the 1-yr growing season. PRE oryzalin and dithiopyr treatments provided the best weed control with very little crop injury. PRE applications of flumioxazin, rimsulfuron, and sulfentrazone did not have adequate crop safety at the rates and timings tested. However, POST-directed applications of flumioxazin and rimsulfuron were much safer to the peach and almond crops and should be evaluated in future trials. Additional herbicides and application techniques are needed to find acceptable, safe control measures for weeds, such as California burclover, common mallow, and redstem filaree, which often are poorly controlled with preplant fumigation in tree nurseries.

Nomenclature: Dithiopyr; flumioxazin; isoxaben; oryzalin; prodiamine; rimsulfuron; sulfentrazone; California burclover, *Medicago hispida* Gaertn. MEDPO; common mallow, *Malva parviflora* L. MALPA; redstem filaree, *Erodium cicutarium* L EROCI; almond, *Prunus dulcis* Mill.; peach, *Prunus persica* Batsch.

Key words: Bare root tree, herbicide screening, methyl bromide alternatives, selectivity, tolerance, tree nursery.

California nurseries produce 60% of the total fruit and nut plants sold in the United States, with an annual value of $165 million to the economy of the state (NASS 2007a). Deciduous fruit and nut trees are a major component of this nursery sector and largely supply planting material for the increase and maintenance of nearly 1.2 million bearing acres of peach, plum (*Prunus domestica* L.), apricot (*Prunus armeniaca* L.), nectarine [*Prunus persica* Batsch var. *nectarina* (Aiton) Maxim.], almond [*Prunus dulcis* (Mill.) D. A. Webb var. *dulcis*], pistachio (*Pistacia vera* L.), and walnut (*Juglans regia* L.) in California alone (NASS 2007b). Traditionally, open field production of deciduous tree nursery stock is a 3- to 5-yr cycle that begins with preplant soil fumigation the summer before the nursery crop is established. Seed or hardwood cuttings of a rootstock are planted in the fall and budded or grafted to a preferred scion variety in spring or summer of the next year. However some nut trees, including walnut and pecan [*Carya illinoinensis* (Wangenh.) K. Koch] are grafted in the spring of the second year because of the preference for larger planting stock in these markets. After reaching target size (usually after one or two growing seasons) and going dormant in the fall, the trees are harvested with an undercutting digger and soil is removed from the roots. The bare-root trees are washed, graded according to trunk diameter and root and stem quality, and heeled-in or held in cold storage before sale to commercial fruit and nut orchards in California and interstate and international markets. Following the tree nursery crop, fields are typically planted with a cover crop or left fallow for 1 to 3 yr.

Producers of field-grown tree and vine nursery stock rely on soil fumigation for broad-spectrum control of a variety of soil-borne pests, including parasitic nematodes, disease pathogens, and weeds (Schneider et al. 2003). For more than 50 yr, methyl bromide (MeBr) has been widely used for soil fumigation in high-value vegetable, fruit, and nursery crops but is currently being phased out because of adverse environmental impacts (UNEP 1999). Intensive research efforts have identified several fumigant treatments that effectively control nematodes and pathogens in some situations (CDFA 2005; Norton 2005). However, none of the currently registered and available chemical alternatives has the same spectrum of activity, pest control efficacy, and grower confidence as MeBr (Duniway 2002).

Even with preplant soil fumigation, weed control in perennial-crop field nurseries is a recurring problem for many producers in the Central Valley of California (Shrestha et al. 2008). Soil fumigation alone often does not provide and maintain a consistently high level of weed control over a 1- to 3-yr crop cycle because of a weed species' biology (impermeable seed coat, dormancy), ecology (airborne invasion, large seed bank), or response to environmental conditions (dry soil) (Hanson and Shrestha 2008). Tree seedlings and newly established cuttings are not very competitive; therefore, even moderate levels of weed infestation can decrease tree crop establishment and productivity (Altland et al. 2003; Willoughby et al. 2006). In nursery crops, weeds can also interfere severely with cultural practices, including budding, grafting, pruning, and various harvest operations. Most perennial crop

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Table 1. Crop production, pest control, and site information for two herbicide/fumigation trials in stone-fruit tree nurseries located near Hickman, CA, and Yuba City, CA, in 2006–2007.

Site conditions	Hickman, CA Stanislaus County	Yuba City, CA Sutter County
Previous crop	2006 wheat/pea cover crop	2006 winter wheat
Last nursery crop	2003 stone-fruit trees	No nursery, long-term orchard
Soil type	Sandy loam	Clay loam
Fumigation date	August 10, 2006	September 9, 2006
Planting date	September 5, 2006	October 11, 2006
Rootstock variety	'Nemaguard' peach	'Nemaguard' peach
PRE herbicide application date	October. 25, 2006	October. 17, 2006
Soil temp at 2 inches	17 C	21 C
Air temperature	22 C	27 C
Humidity	33%	31%
Soil condition	Dry, small clods	Dry surface
POST-directed herbicide application date	March 7, 2007	March 1, 2007
Soil temp at 2 inches	21 C	7 C
Air temp	29 C	12 C
Humidity	36%	55%
Soil condition	Dry surface	Wet surface
Overspray herbicide treatment	None	Glyphosate, January 15, 2007
Budding date	June 22, 2007	June 4, 2007
Scion variety	Several[a]	'Monterey' almond
Final evaluation date	November 16, 2007	December 6, 2007
Tree harvest	November 20, 2007	December 20, 2007

[a] The Hickman, CA, location was budded with several scion varieties. The trees in the 1,3-D block were budded with 'Folsom' almond and an experimental almond variety, whereas the trees in the methyl bromide block were budded with two experimental peach and two experimental nectarine varieties.

nursery production systems currently rely on a combination of preplant soil fumigation, PRE herbicides, and extensive tillage and hand-labor during the growing season for acceptable weed control. Currently, PRE and early POST herbicide choices are limited by the number of registered materials and by crop safety concerns (Zheljazkov et al. 2007). Herbicides likely will become an even more important weed management tool in tree nurseries as MeBr becomes less available and labor and fuel costs continue to rise (Altland et al. 2003; Gilliam et al. 1989).

Identification of herbicides and herbicide application techniques that provide effective, nonphytotoxic, in-season weed control in perennial crop field nurseries will provide growers with additional management options for effective and economical production of fruit and nut tree nursery stock. The specific objectives of this study were to determine (1) weed control efficacy of several PRE and POST herbicide treatments in a stone-fruit tree field nursery, (2) the impact of the herbicide treatments on crop establishment, and (3) the effect of treatments on the health, vigor, and productivity of the crop.

Materials and Methods

Two nursery trial sites were identified near Hickman, CA, and Yuba City, CA, in the central and northern part of California's Central Valley, respectively. The soil at the Hickman, CA, site was a sandy loam with pH 7.3, 1.1% organic matter, and 68% sand, 16% silt, and 16% clay. At the Yuba City, CA, site, the soil was a silty-clay loam with pH 7.1, 2.2% organic matter, and 19% sand, 51% silt, and 30% clay. Because preplant fumigation or extensive soil and root sampling is necessary to meet nematode-free certification requirements, most nursery operations will continue to use either MeBr (under Quarantine and Preshipment or under Critical Use Exemptions) or 1,3-dichloropropene fumigants (CDFA 2005). Thus, the cooperating growers prepared the fields for preplant fumigation using appropriate tillage and soil moisture management techniques. At each location, two 0.12-ha areas were commercially fumigated (TriCal Inc., Hollister, CA) with 392 kg/ha of 98 : 2 MeBr or 372 kg/ha 1,3-dichloropropene (1,3-D), respectively (Table 1). The two fumigation blocks were 10 to 30 m apart in each field. MeBr was applied with a Noble plow fumigation rig, with injection points 30 cm deep and a spacing of 30 cm between nozzles, and using a roller and standard (high-density polyethylene, HDPE) tarp on the rig. The 1,3-D treatments were applied with a modified Telone fumigation rig, with injection points 46 cm deep, and with a spacing of 51 cm between nozzles and was followed by the Noble plow rig to lay the HDPE tarp. Each location also had an unreplicated, unfumigated area ($\sim$0.04 ha) for evaluation of pest pressure. At the Yuba City, CA, site, an additional tarp vs. no-tarp comparison was conducted in the nonfumigated area to evaluate the effects of solarization. Tarps remained on the experimental plots for approximately 3 wk.

The cooperating growers prepared the seed bed for planting and seeded 'Nemaguard' peach seed in fall 2006 (Table 1). The crop was planted 8 cm apart with 1.5 m between rows at the Hickman, CA, site and 15 cm apart with 1.4-m row spacing at the Yuba City, CA, site. A total of 15 herbicide treatments were applied to both the MeBr and 1,3-D blocks (Table 2). PRE herbicide treatments (treatments 2–10 and 15) were applied in a 0.9-m band over the seed row after seeding of the peach rootstock, using a CO_2-pressurized backpack sprayer calibrated to deliver 187 L/ha. The Yuba City, CA, cooperator also applied a broadcast glyphosate treatment over all plots in January 2007 to control existing

Table 2. Weed population counts on March 15, 2007 (4.5 mo after initial treatment), in a nursery experiment near Hickman, CA, and on April 17, 2007 (5 mo after initial treatment), in a nursery experiment near Yuba City, CA. Weeds were counted in a 25-cm untilled strip in the tree seedling row.[a]

Treatment				Hickman, CA site		Yuba City site					
				Total weeds[b]		Total weeds[c]		Common mallow		California burclover	
No.	Herbicide	Rate	Timing	MeBr	1,3-D	MeBr	1,3-D	MeBr	1,3-D	MeBr	1,3-D
		kg ai/ha		No. weeds/7.6 m of row							
1	No-herbicide	—	—	15	6	44	38	29	26	13	10
2	Oryzalin	1.12	PRE	1	0	16	20	7	10	10	9
3	Prodiamine	1.12	PRE	1	2	29	34	15	12	13	17
4	Isoxaben	1.12	PRE	0	0	11	12	9	7	0	0
5	Flumioxazin	0.14	PRE	1	2	2	3	0	0	2	1
6	Flumioxazin	0.28	PRE	0	0	0	21	0	0	0	0
7	Rimsulfuron	0.071	PRE	2	1	14	17	14	17	0	0
8	Dithiopyr	1.12	PRE	0	0	1	1	1	0	0	1
9	Sulfentrazone	0.14	PRE	22	3	11	21	7	7	3	12
10	Sulfentrazone	0.28	PRE	7	3	14	14	6	4	5	4
11	Flumioxazin	0.14	POST-D	3	9	43	33	34	21	8	11
12	Flumioxazin	0.28	POST-D	2	3	43	35	37	19	7	14
13	Rimsulfuron	0.071	POST-D	12	5	28	26	23	20	3	3
14	Dithiopyr	1.12	POST-D	9	6	26	28	17	14	9	9
15	Oryzalin fb flumioxazin	1.12 fb 0.14	PRE fb POST-D	20	2	7	15	3	4	3	10
LSD (0.05)				15	4	19	17	18	13	7	11

[a] Abbreviations: No., number; fb, followed by; POST-D, POST-directed; MeBr, methyl bromide; 1,3-D, 1,3-dichloropropene.

[b] Primary weeds at Hickman, CA, were common mallow, California burclover, common chickweed, and horseweed along with low numbers of several other winter annual weed species.

[c] Primary weeds at Yuba City, CA, were common mallow, California burclover, annual ryegrass, annual sowthistle, prostrate knotweed, and common chickweed.

weeds before rootstock emergence. Following tree emergence in the spring, the POST-directed (POST-D) treatments (treatments 11–15) were applied in 187 L/ha of water using a drop-nozzle boom equipped to spray a band on either side of the tree row. The nozzles were arranged so that the spray pattern was 46 cm wide on each side of the tree row and the bands met at the base of the trees to minimize foliar herbicide exposure. Individual herbicide plots were 1 m wide by 7.7 m long, containing a single tree row, and each treatment was replicated four times in each fumigation block.

The cooperating nurseries thinned, budded, pruned, and fertilized the rootstock and budded the trees according to their standard production practices (Table 1). Emerged rootstock and weeds were counted in an area 25 to 30 cm wide by 7.6 m long on March 15 and April 17, 2007 at the Hickman, CA, and Yuba City, CA, locations, respectively. Weed control and tree vigor were visually monitored throughout the growing season, although the experimental sites were cultivated and hand-weeded as appropriate by the nursery operations. A few weeks before harvest, on November 16, 2007, at Hickman, CA, and December 6, 2007, at Yuba City, CA, the number of successfully budded trees in 3 m of row was recorded in each plot. Trunk caliper of 10 trees in each plot (if possible), 5 cm above the graft union was measured and used to determine harvest grade in each plot. Because the cooperating growers harvested the bare-root trees along with the surrounding tree stock, no postharvest data were collected.

Field constraints and fumigation logistics required each fumigation block to be treated as a separate, randomized complete block at each nursery. All data were subjected to ANOVA, and means were separated using Fisher's Protected LSD test with $\alpha = 0.05$.

Results and Discussion

At the Hickman, CA, location, the rootstock emerged in February and March 2007. There were several hundred weeds per square meter in the unfumigated area, consisting primarily of shepherd's purse (*Capsella bursa-pastoris* L), annual sowthistle (*Sonchus arvensis* L), and California burclover (*Medicago hispida* Gaertn). Weed populations in the 1,3-D and MeBr fumigated blocks were low and consisted primarily of common chickweed (*Stellaria media*), California burclover, and common mallow (*Malva neglecta* Wallr.). An interrow tillage operation in early March removed most of the weeds between the herbicide-treated bands in the fumigated blocks but did little to relieve weed competition within the row in the unfumigated area (data not shown). On March 15, 2007 (4.5 mo after PRE treatment), all PRE treatments, except sulfentrazone, substantially reduced total weeds in the tree rows compared with the no-herbicide control (Table 2). Control with the POST-D treatments was poor, but those treatments may not have reached full impact having been applied only 2 wk before the weed counts. Later observations suggested that POST-D flumioxazin and rimsulfuron also suppressed many of the weeds present (data not shown). Although total weed counts were different among herbicide treatments, this was largely driven by winter annual weeds, such as shepherd's purse and annual sowthistle. Counts of the major hard-to-fumigate weeds, including mallow, burclover, and redstem filaree, were variable and not different among treatments. Following the mid-March rating, both fumigation blocks were cultivated and hand-weeded according to the nurseries' standard schedules, and further detailed weed counts were not conducted. Because of early season crop

Table 3. Effect of herbicide and fumigation treatments on rootstock emergence and bud success in two stone-fruit nursery field trials near Hickman, CA, and Yuba City, CA, in 2006–2007.[a]

Treatment				Hickman, CA, site[b]				Yuba City, site[c]			
				Rootstock emergence		Budded trees		Rootstock emergence		Budded trees	
No	Herbicide	Rate	Timing	MeBr	1,3-D	MeBr	1,3-D	MeBr	1,3-D	MeBr	1,3-D
		kg ai/ha		No./7.6 m of row							
1	No-herbicide	—	—	100	106	54	50	41	47	35	38
2	Oryzalin	1.12	PRE	105	105	58	43	31	31	35	40
3	Prodiamine	1.12	PRE	115	106	52	52	24	27	35	38
4	Isoxaben	1.12	PRE	76	54	60	37	38	37	38	40
5	Flumioxazin	0.14	PRE	69	53	36	30	33	41	21	35
6	Flumioxazin	0.28	PRE	34	51	28	22	29	40	20	29
7	Rimsulfuron	0.071	PRE	30	46	8	2	31	32	6	14
8	Dithiopyr	1.12	PRE	96	114	56	45	31	50	33	38
9	Sulfentrazone	0.14	PRE	66	72	2	11	25	50	23	31
10	Sulfentrazone	0.28	PRE	18	30	0	0	30	42	8	6
11	Flumioxazin	0.14	POST-D	106	98	59	53	21	36	28	36
12	Flumioxazin	0.28	POST-D	107	101	56	44	33	47	25	31
13	Rimsulfuron	0.071	POST-D	106	105	59	51	22	23	28	36
14	Dithiopyr	1.12	POST-D	100	93	49	47	33	45	35	34
15	Oryzalin fb flumioxazin	1.12 fb 0.14	PRE fb POST-D	102	114	51	49	31	42	31	35
	LSD (0.05)			27	30	17	17	ns	ns	10	11

[a] Abbreviations: No., number; fb, followed by; POST-D, POST-directed; MeBr, methyl bromide; 1,3-D, 1,3-dichloropropene; ns, not significant.

[b] Rootstock was 'Nemaguard' peach in both fumigation blocks at the Hickman, CA, site; however, the MeBr block was grafted to several peach and nectarine varieties, whereas the 1,3-D block was grafted to a mixture of almond cultivars. Rootstock emergence was recorded on March 15, 2007, and the number of successfully budded trees was recorded on November 16, 2007.

[c] At the Yuba City, CA, site, the rootstock was 'Nemaguard' peach, and the scion variety was 'Monterrey' almond in both fumigation blocks. Rootstock emergence was recorded on April 17, 2007, and the number of successfully budded trees was recorded on December 6, 2007.

injury and reduced crop competition, weed control was poorer than expected with PRE flumioxazin, rimsulfuron, and sulfentrazone by the end of the growing season (data not shown, crop injury discussed below).

The Yuba City, CA, location, which had been a long-term nut orchard until 2004 and had two winter wheat (*Triticum aestivum* L.) crops grown before this nursery crop, had substantially higher weed populations than the Hickman, CA, site (Table 2). In December 2006, before crop emergence, the primary weeds in the unfumigated area were volunteer wheat, annual ryegrass (*Lolium multiflorum* Lam), and low populations of winter-annual broadleaf weeds, including common chickweed, annual sowthistle, and horseweed (*Conyza canadensis* L). No differences in weed populations were observed in the unfumigated tarped vs. untarped plots. The two fumigated blocks had primarily California burclover, common mallow, and some annual grasses emerging by early January. In mid-January, the cooperating nursery oversprayed the trial with glyphosate to control emerged weeds before rootstock emergence. A weed count on April 17, 2007 (5 mo after PRE treatment), indicated that most PRE treatments, except for prodiamine and rimsulfuron, increased weed control over fumigation and broadcast glyphosate alone. Interestingly oryzalin, a grower standard, did not reduce burclover populations at the 1.12 kg/ha rate tested; however, higher rates used by the grower, outside of the experimental area, provided better suppression of this and other weeds (data not shown). After April, the nursery cultivated and hand-weeded the trial along with the surrounding field, and no further detailed weed counts were conducted.

Crop safety is of paramount importance in nursery tree production because stunting or visual root defects could substantially reduce the number or value of saleable trees at harvest. Substantial injury to the emerging rootstock was observed with several treatments at the Hickman, CA, location before thinning (Table 3). PRE flumioxazin, rimsulfuron, and sulfentrazone reduced rootstock emergence in both fumigation blocks, whereas isoxaben reduced emergence only in the 1,3-D block. PRE oryzalin, dithiopyr, and prodiamine did not injure the emerging peach seedlings. Flumioxazin and sulfentrazone severely injured the peach rootstock as the coleoptile reached the soil surface; however, almond grown on hardwood plum cuttings in a related nursery experiment did not have the same injury with these herbicides, likely because the shoot did not have to emerge through the treated zone (B. D. Hanson, unpublished data). Because of the high rootstock mortality, the number of successfully budded trees was reduced by all PRE flumioxazin, rimsulfuron, and sulfentrazone treatments; however, after the prebudding thinning operation, the isoxaben treatment in the 1,3-D block was no longer different from the control.

At the Yuba City, CA, location, rootstock emergence was somewhat variable among treatments, and no differences were observed (Table 3). However, substantial stunting of the rootstock was observed with several treatments, which directly affected the number of successfully budded trees in plots treated with PRE flumioxazin, rimsulfuron, and sulfentrazone in most cases.

There were differences in tree-size class distribution near harvest; however, at the Hickman, CA, site, this was primarily

Table 4. Effect of herbicide and fumigation treatments on tree-size class distribution on November 16, 2007, before harvest in a stone-fruit[a] nursery field trial near Hickman, CA, in 2006–2007.[b]

Treatment No.	Herbicide	Rate	Timing	6.4 to 9.4 mm MeBr	6.4 to 9.4 mm 1,3-D	9.5 to 15.8 mm MeBr	9.5 to 15.8 mm 1,3-D	15.9 to 25.4 mm MeBr	15.9 to 25.4 mm 1,3-D
		kg ai/ha		No.[c]					
1	No-herbicide	—	—	1	2	6	7	3	1
2	Oryzalin	1.12	PRE	2	2	8	7	1	1
3	Prodiamine	1.12	PRE	1	3	7	7	3	1
4	Isoxaben	1.12	PRE	3	2	5	7	3	2
5	Flumioxazin	0.14	PRE	1	2	6	7	3	2
6	Flumioxazin	0.28	PRE	2	1	4	6	4	1
7	Rimsulfuron	0.071	PRE	0	0	2	1	1	0
8	Dithiopyr	1.12	PRE	1	1	9	8	1	1
9	Sulfentrazone	0.14	PRE	0	0	0	3	0	1
10	Sulfentrazone	0.28	PRE	0	0	0	0	0	0
11	Flumioxazin	0.14	POST-D	0	1	9	9	1	0
12	Flumioxazin	0.28	POST-D	2	1	7	9	1	0
13	Rimsulfuron	0.071	POST-D	1	1	9	8	1	1
14	Dithiopyr	1.12	POST-D	1	2	8	8	1	0
15	Oryzalin fb flumioxazin	1.12 fb 0.14	PRE fb POST-D	1	2	7	8	2	0
LSD (0.05)				2	ns	2	3	2	ns

[a] Rootstock was 'Nemaguard' peach in both fumigation blocks; however, the MeBr block was budded to several peach and nectarine varieties, whereas the 1,3-D block was budded to a mixture of almond cultivars.

[b] Abbreviations: No., number; fb, followed by; POST-D, POST-directed; MeBr, methyl bromide; 1,3-D, 1,3-dichloropropene, ns, not significant.

[c] Average number of trees in each size class out of 10 measured.

influenced by tree mortality from rimsulfuron and sulfentrazone treatments (Table 4). Interpretation of tree caliper data at the Hickman, CA, site was confounded by the variety of fruit and nut cultivars budded in the trial area. Similar to the Hickman, CA, site, there were differences in size class distribution at the Yuba City, CA, site (Table 5). Generally, treatments that reduced rootstock emergence or budding success, also had more small-caliper trees at harvest at Yuba City, CA. Although it could not be tested statistically, there appeared to be more small (6.4- to 9.4-mm-diam) trees in the 1,3-D block compared with MeBr, which tended to have more large (15.9- to 25.4-mm-diam) almond trees. Although differences in size class distribution were often small, a nursery producer could experience a significant economic effect, depending on sales contracts and prices. Current market preference in California orchards for almond planting stock is

Table 5. Effect of herbicide and fumigation treatments on tree size class distribution on December 6, 2007, before harvest in an almond[a] nursery field trial near Yuba City, CA, in 2006–2007.[b]

Treatment No.	Herbicide	Rate	Timing	6.4 to 9.4 mm MeBr	6.4 to 9.4 mm 1,3-D	9.5 to 15.8 mm MeBr	9.5 to 15.8 mm 1,3-D	15.9 to 25.4 mm MeBr	15.9 to 25.4 mm 1,3-D
		kg ai/ha		No.[c]					
1	No-herbicide	—	—	3	5	8	5	0	0
2	Oryzalin	1.12	PRE	1	6	9	4	0	0
3	Prodiamine	1.12	PRE	4	4	6	7	0	0
4	Isoxaben	1.12	PRE	4	3	6	7	1	0
5	Flumioxazin	0.14	PRE	0	4	8	6	0	0
6	Flumioxazin	0.28	PRE	1	1	7	7	0	0
7	Rimsulfuron	0.071	PRE	2	2	1	2	0	0
8	Dithiopyr	1.12	PRE	4	5	6	5	0	0
9	Sulfentrazone	0.14	PRE	2	4	7	6	0	0
10	Sulfentrazone	0.28	PRE	1	1	2	1	0	0
11	Flumioxazin	0.14	POST-D	2	6	7	4	0	0
12	Flumioxazin	0.28	POST-D	2	4	7	6	0	0
13	Rimsulfuron	0.071	POST-D	2	5	7	5	0	0
14	Dithiopyr	1.12	POST-D	2	4	8	6	1	0
15	Oryzalin fb flumioxazin	1.12 fb 0.14	PRE fb POST-D	2	2	8	6	1	0
	LSD (0.05)			1	1	1	1	ns	ns

[a] Rootstock was 'Nemaguard' peach, and the scion variety was 'Monterey' almond in both fumigation blocks.

[b] Abbreviations: No., number; fb, followed by; POST-D, POST-directed; MeBr, methyl bromide; 1,3-D, 1,3-dichloropropene, ns, not significant.

[c] Average number of trees in each size class out of 10 measured.

for trees with 12.7- to 19-cm caliper measurement (R. Woolley, personal communication).

Overall, weed control in these two trials was not substantially different between the blocks fumigated with 392 kg/ha MeBr or 372 kg/ha 1,3-D. Several PRE herbicide treatments, following either preplant fumigant, provided significant early season weed control in stone-fruit nursery trees, although crop safety was not always adequate. At both locations, with either relatively low or high weed populations, weed control was improved with PRE oryzalin, isoxaben, and dithiopyr, compared with fumigation and tillage alone. In general, POST-D treatments alone were not as effective as PRE treatments, although the former were much safer for the emerging rootstock. Additional research is needed on chemicals or application techniques to provide safe, economical control of weeds, such as burclover, mallow, and redstem filaree, which can escape fumigation and many PRE herbicides. Although the POST-D and combination treatments in these trials were not as effective as expected, it is likely that a combination approach with preplant fumigation, PRE herbicides, and POST-D treatments can increase weed control and provide economic savings to nursery tree producers.

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